Indiana’s Science, Technology, Engineering, and Mathematics (STEM) Initiative Plan

“America’s high schools are obsolete. By obsolete, I don’t just mean that our high schools are broken, flawed, and under-funded – though a case could be made for every one of those points By obsolete, I mean that our high schools – even when they’re working exactly as designed – cannot teach our kids what they need to know today.” -Bill Gates

INTRODUCTION

Over the past four years, the Indiana Department of Education (IDOE) has led the most ambitious educational reform in Indiana’s history. These comprehensive reforms were put in place to elevate the academic achievement and career preparation of all Indiana students to be the best in the United States and on par with the most competitive countries in the world. It is apparent, not only in Indiana but across the country, that the education students receive does not provide them with the knowledge and skills necessary for success in college and careers.

For this reason, a group of educators and business leaders from across Indiana, has developed a plan for STEM education[1], a non-traditional model of education, as one option to close the widening gap between the knowledge and skills of our students and the rigorous demands of college and careers. Expectations have changed for today’s students as data will show, and so we must change the model of how we educate students. Schools cannot continue educating students the same way they have for decades and expect different results.

For the purposes of this plan, the following commonly accepted definition of STEM education will be used:

> "STEM education is an intentional, metadisciplinary approach to teaching and learning, in which students uncover and acquire a cohesive set of concepts, competencies, and dispositions of science, technology, engineering, and mathematics that they transfer and apply in both academic and real-world contexts, in order to be globally competitive in the 21st Century."
>
> -Rider-Bertrand 2007

The National Governor’s Association Initiative, “Innovation America,” has identified specific skills that a new workforce will need to drive our nation’s innovation and economy. Our graduates must be adept problem solvers, innovators, and inventors who are also self-reliant. They must be able to think logically and work both independently and collaboratively. They must possess the confidence and understanding to know when and how to appropriately use the tools and technology that enhance success in STEM-related fields. The key to developing these skills is strengthening Science, Technology, Engineering, and Mathematics (STEM) competencies in every K–12 student.

[1] Modified from the STEM Immersion Matrix for Schools and Districts © 2012, The Immersion Guide © 2013, created by and work product of The Arizona STEM Network, led by Science Foundation of Arizona in collaboration with Maricopa County Education Service Agency.

Indiana's Science, Technology, Engineering, and Mathematics (STEM) Initiative Plan

Indiana's Vision and Mission for STEM Education

IDOE Vision

The academic achievement and career preparation of all Indiana students will be the best in the United States and on par with the most competitive countries in the world.

Mission

All schools will have the opportunity, funding, partnerships, support and guidance to provide quality STEM Education to all students. In addition, all students, regardless of demographic, location, or disability, will be provided an education that allows opportunities to gain the knowledge and skills necessary for success in college and careers.

Our mission is to (1) provide resources and support to schools in order to enhance science, technology, engineering, and math curriculum with a greater emphasis on discovery and relevant workforce skills; and (2) outline methodologies necessary to ensure its successful implementation.

Indiana's STEM Education goals

1. Align with Indiana Department of Education's goals. Ms. Glenda Ritz, Superintendent of Public Instruction for the State of Indiana, has set the bar high by promoting a culture of academic excellence
    a. Give more time for teaching and less time on testing
    b. Give more control to the local school districts
    c. Make sure every child is safe and respected
    d. Make teacher licensing and evaluation standards top in the nation
    e. Clear barriers to quality vocational education
2. Increase the availability of STEM education to all students to produce STEM literate students who become productive members of our state.
3. Produce students who are able to apply understanding of how the world works within and across the four interrelated domains of STEM by developing STEM literacy.
4. Develop programs and partnerships that allow all students to engage in science, technology, engineering, and mathematics (STEM) education.
5. Increase public awareness of and support for a P-16 STEM education system as an integral part of improving high school graduation rates and enhancing the state's innovation capacity.
6. Reduce the number of students needing remediation upon matriculation to postsecondary institutions.
7. Create partnerships with post-secondary institutions, education, and business and industry to support the educational needs of students that are critical to our workforce.
8. Prepare students, teachers and schools for the change to Indiana Common Core Standards which require a fundamental change in teaching and student performance.

State of STEM Education in Indiana

The need to improve STEM education in Indiana is reflected in a growing demand for Indiana students to be on par with peers both in the United States and in competitive countries around the world. In 2011, 78% and 77% of Indiana's 4th and 8th graders passed the Indiana Statewide Test of Educational Progress (ISTEP+) math exam; however, only 44% and 34% of students were found to be proficient according to the National Assessment of Educational Progress (NAEP). While the NAEP sample size is very small compared to the number of students taking ISTEP+, the information still bears notice. Indiana has a large achievement gap between white, Hispanic and black students. According to NAEP, 51% of white 4th grade students were proficient in Math compared to 29% for Hispanics and 15% for black students. This deficit is similar in 8th grade Science as well: 41% of white 4th grade students were proficient in Science compared to 15% of Hispanics and only 9% of black students.

A deep understanding of mathematics and science is critical to an individual's success beyond high school, expanding career options, and increasing earning power. Data from ISTEP+, found in Appendix A, reveal that the percentage of students passing the mathematics portion of ISTEP+ has improved to 79% at the 4th grade level and passing scores on the science portion increased 2%. These data and others suggest that, although Indiana students have made progress in mathematics and science, additional progress is needed to reach our goals.

According to the U.S. Department of Education's National Center for Education Statistics (NCES), only 45% of high school graduates in the U.S. were ready for college level math and only 30% were ready for postsecondary science. Quite simply, a majority of the students we are educating are not ready for college and careers and likely will not be competitive in a global economy. One of the leading indicators for success in college is taking AP courses in high school. Only 12% of Indiana students take AP courses in math and 11% in science. Furthermore, only 5% of Indiana's student's receive a score of 3 or higher on the AP exam in math and only 3% in science. Of students who go to college, only 56.4% of students graduate with a bachelor's degree within 6 years of matriculation and only 38% of the 18-24 year old age group go to college. Of those college attendees, only 11.9% of majors are in STEM fields. In addition, of the students who do go to college, 64% require remediation costing the state $16,225,502 each year (Change The Equation, 2012).

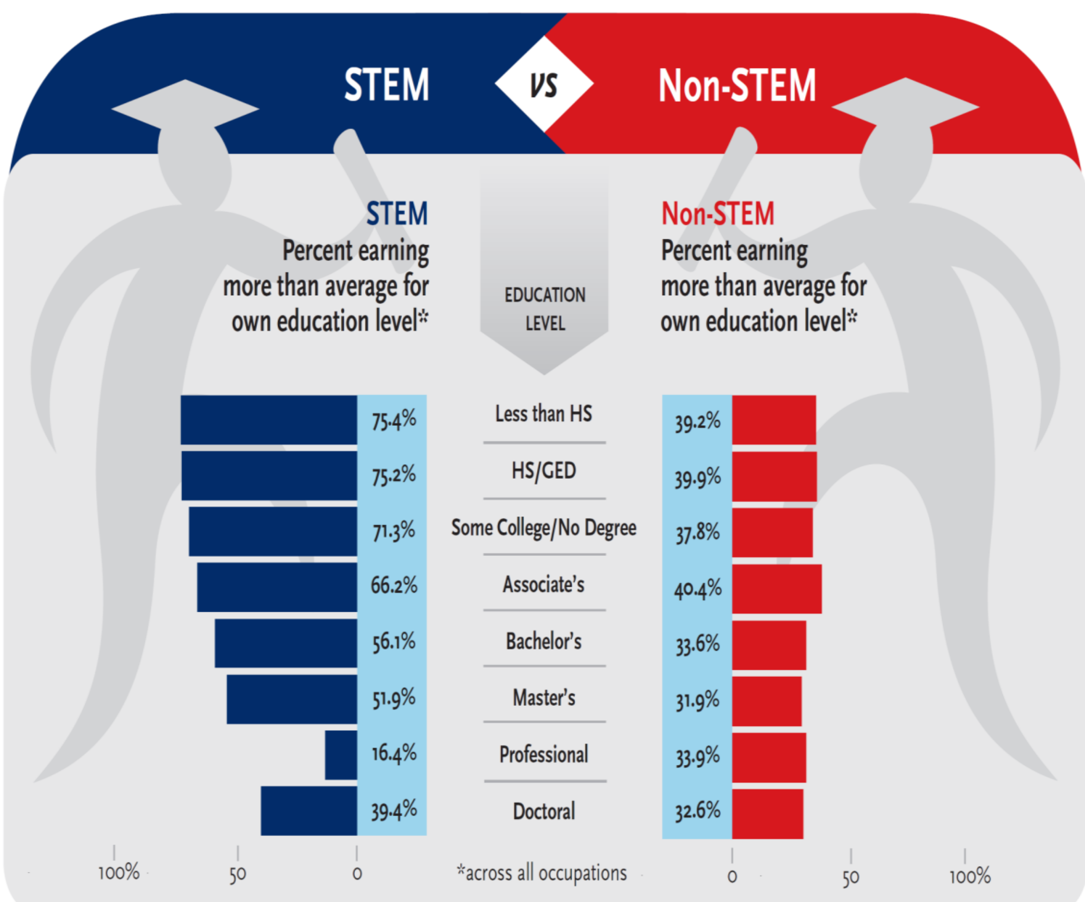
Not only is Indiana concerned with developing college and career skills through STEM education, but we also look to increase student engagement, well-being, and perceptions of schooling. School should be an enriching environment that constantly challenges and forces students to expand their abilities. According to Indiana University's 2009 High School Survey of Student Engagement, 66% of students are bored at least every day in class. Only 2% of students reported never being bored. Reasons for boredom included material not being interesting (cited by 82% of respondents) material not being relevant (41%), and no student interaction with the teacher (34%). These data related to boredom highlight a severe issue that many schools grapple with: high incidence of student drop outs.

Across this country, roughly 25% of students do not graduate high school on time. In Indiana, only 72% of 9th graders graduated in four years. Students cite various reasons for why they do not complete high school on time, including lack of interest in, purpose for, and relevance of schoolwork. In addition, the most cited reasons for students that drop out of school altogether is (1) they do not like school; (2) they do not see the value of the work; (3) they do not like teachers; and (4) they do not feel challenged (Yazzie-Mintz, 2009). STEM education, when implemented with fidelity, can help to resolve the issues with student boredom.

STEM Workforce

According to Georgetown University's Center on Education and the Workforce State-level Analysis on STEM, Indiana will demand a total of 115,570 STEM jobs by 2018, up from 105,560 in 2008. These jobs provide tremendous financial opportunity for Indiana students, as the average STEM occupation salary is $74,958, compared to an average of $45,563 for all jobs. The education level required for these jobs, however, is also much higher: 90% of STEM-related jobs will require training beyond a high school diploma, compared to just 55% of all jobs in Indiana. STEM jobs also are going unfilled – there are two job openings for every 1 person applying to STEM occupations, but there are on average 3.6 people applying to every job opening in other fields (Change The Equation, 2012). Because of this, by 2018 there will be a shortage of 3,000,000 workers with U.S. college degrees (Carnevale, A.P., Smith, N., and Srohl, J., 2010). This will increase the reliance of U.S. business on foreign labor in high-wage, high-skill positions as Asian countries continue to provide a pipeline of qualified workers for STEM occupations: from 1980-2000, China increased Engineering graduates by 161%, Japan by 42%, and South Korea by 140%, while the U.S. decreased by 20%. For our students to remain competitive in the workforce, we must produce more STEM graduates.

As shown in the graphic below, people who have the same level of education working in STEM typically earn more than their counterparts working in non-STEM fields.



STEM Education Defined

STEM education is an interdisciplinary literacy that seeks to integrate, in whole or in part, the four areas of science, technology, engineering, and mathematics into a comprehensive and coherent curriculum across content areas. STEM literacy includes, but does not simply mean, achieving independent literacy in these four strands; rather, STEM literacy focuses on relevant integration alongside independent literacy.

A STEM classroom is a non-traditional classroom that shifts students away from learning discrete bits and pieces of phenomenon and rote procedures but works toward investigating and questioning the interrelated facets of the real world. STEM education aims to develop a student's ability to think logically, solve problems, innovate in both academic and real-world contexts, engage in inquiry, collaborate with peers, and self-motivate. When explicit instruction does not make connections across STEM disciplines, isolated courses and coursework may prevent our students from building necessary competencies and connections among the four STEM disciplines. STEM education intentionally makes the connections across subjects where appropriate. It requires a pedagogical shift in instruction that connects education to students own interests and experiences. STEM education is also meant to be equitable, providing all students' opportunities to learn, develop, and acquire skills that will provide success in life.

STEM Disciplines:

Science instruction develops students' ability to use scientific knowledge (in physics, chemistry, biological sciences, and earth/space sciences) and processes not only to understand the natural world, but to participate in decisions that affect it (in three main areas — science in life and health, science in Earth and environment, and science in technology).

Technology instruction develops students' ability to use, manage, understand, and assess technology. Students should know how to use new technologies, understand how new technologies are developed, and have skills to analyze how new technologies affect us, our nation, and the world. Technology is the innovation, change, or modification of the natural environment to satisfy perceived human needs and wants.

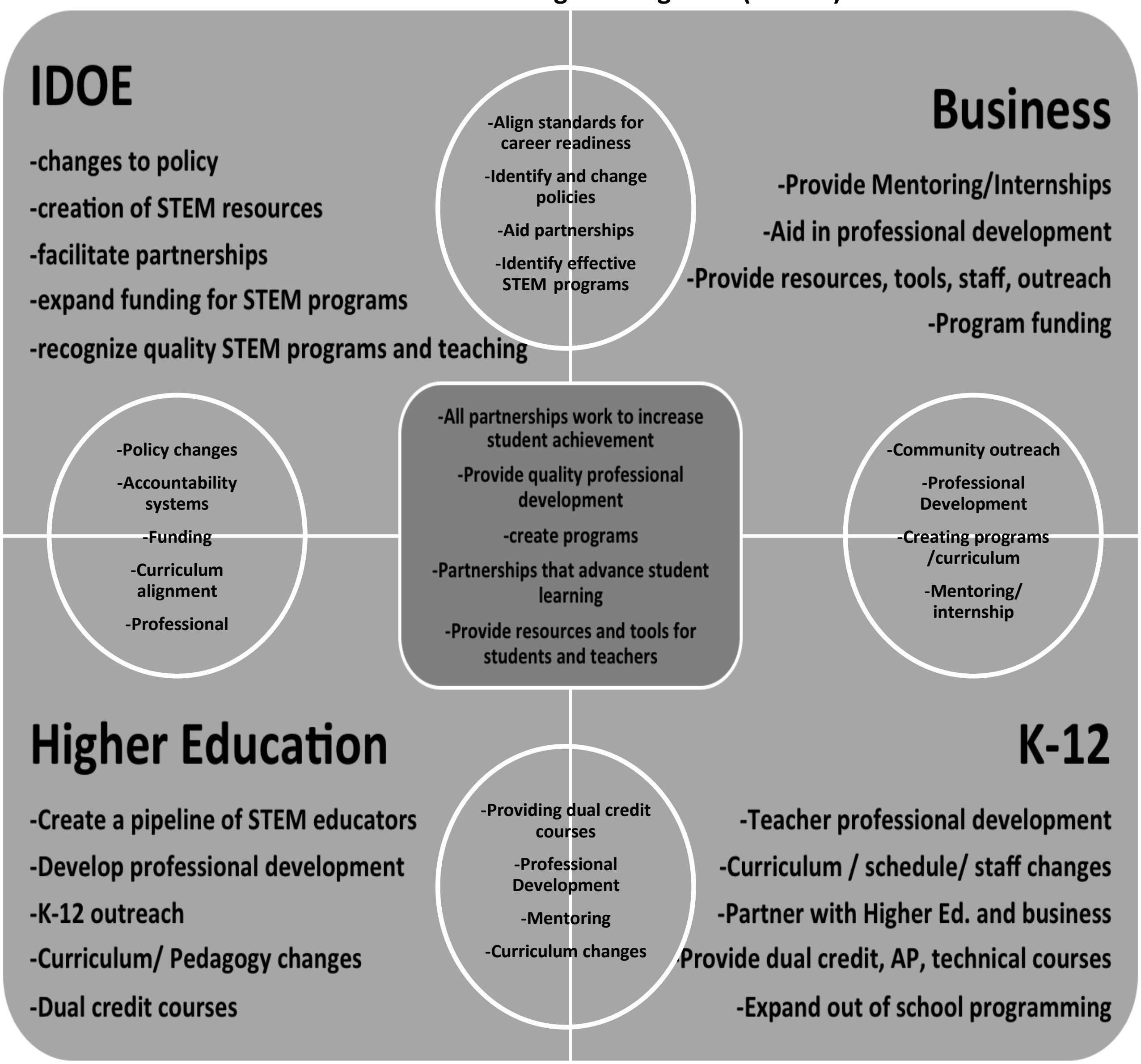
Engineering instruction develops students' understanding of how technologies are developed via the engineering design process. Lessons are project-based and integrate multiple subjects, making difficult concepts relevant and tangible to students and tapping into students' natural interest in problem-solving. Engineering design is the systematic and creative application of scientific and mathematical principles to practical ends such as the design, manufacture, and operation of efficient and economical structures, machines, processes, and systems.

Mathematics instruction develops students' ability to analyze, reason, and communicate ideas effectively as they pose, formulate, solve, and interpret solutions to mathematical problems in a variety of situations.

STEM Components for Implementation

Successful implementation of any program is related to the particular settings of the learning environment. Most implementations of STEM education in K-12 schools have centered on the "S and M" of STEM, and not fully on "S, T, E, and M". Engineering and technology have not received equal attention in the current version of STEM education (Hayes, 2009). Schools must move toward implementation of any STEM program being mindful of the context of their school dynamics. Research indicates three keys topics to successful implementation: support structures, professional development/teacher recruitment, and assessment practices. For Indiana's STEM plan, these topics are the responsibility of the school, post-secondary institutions, business and industry, and the Indiana Department of Education. It is through these entities the STEM Plan will be divided.

Collaboration: Putting it all together (chart 1)



Component: K-12

The K-12 component includes elements that Indiana believes to provide sustained improvement to the education of Indiana's students, kindergarten through 12^{th} grade. The following elements to be discussed include STEM students, STEM Schools, assessment, curriculum, professional development, collaboration, and accountability.

K-12: STEM Students

Indiana acknowledges that not every student will enter a STEM industry, we recognize that other industries are becoming increasingly reliant upon STEM knowledge and skills. Nearly all career paths, regardless of how closely aligned they are with the traditional STEM disciplines, require students to be proficient in the STEM disciplines and/or have the skills provided by STEM education.

This plan will provide the basis for two types of STEM student: the student who graduates high school *proficient* in STEM disciplines and the student who graduates high school *advanced* in STEM disciplines. These two types of students are defined below, based on the career opportunities become available for each type of student.

The STEM Proficient Student

The charge for a STEM-proficient workforce comes not just from STEM-related groups such as the National Science Foundation, but from business and commerce groups as well, such as the Business Roundtable and the Department of Labor. According to the Department of Labor, STEM Proficient students should have the basic skills necessary for the workforce or entering college for fields other than STEM. Specific criteria regarding the STEP Proficient Student, including core knowledge and course requirements can be found in Appendix B.

The STEM Advanced Student

For those students who plan on pursuing a STEM major at the postsecondary level, simply being "proficient" in STEM upon high school graduation will put them at a disadvantage. These students will compete against top international peers from countries that continue to outperform the United States in both math and science. Once again, the Department of Labor has identified STEM Advanced students as those who can also immediately enter the workforce but are also prepared to enter and be successful in STEM majors in college.

According to Martin Jischke, the former president of Purdue University, current trends project that soon nearly 90% of all scientists and engineers in the world will live in Asia. Bill Gates once said, "In the international competition to have the biggest and best supply of knowledge workers, America is falling behind." In order to be competitive with international peers upon college matriculation, our students should graduate from high school as "advanced" in the STEM disciplines. Manufacturing has left America in the pursuit of cheaper labor in other countries, so too will America's Science and Technology to pursue an educated workforce.

The STEM Advanced student will have all the expectations of the STEM Proficient student and additional requirements found in Appendix B.

K-12: STEM Schools

More and more schools across Indiana and the country have identified the need for STEM education for their students. These schools have realized that a high quality STEM education will prepare students for college and careers and provide students with the skills necessary to work in a 21st century workforce. In the following section, this plan will provide guidance for schools to become a recognized STEM School; as well as provide assistance to determine the depth of STEM learning that is best suited for their students.

Evolving into a STEM school environment is much more than introducing a program. For schools, this requires establishing a common local agenda to significantly improve student performance, incorporating STEM education at all levels, engaging local business and the community, and adopting new curriculum and instructional practices. A school's success depends on prioritizing STEM and putting in place effective models that best meet student needs. This plan identifies the four main levels of STEM school immersion and the components that are necessary to become a STEM model school. The STEM Immersion matrix serves as a guide for identifying and creating Total STEM Immersion, Partial STEM Immersion, Minimum STEM Immersion, and Supplementary STEM Immersion and can be found in the appendix C.

K-12: STEM Curriculum

Simply because a course is categorized as a science, technology, engineering, or mathematics course does not ensure that students will actually build competencies in STEM. STEM competencies extend beyond the content in the course, and teachers must be explicit in building these competencies. The following observations provide guidance for schools and teachers to ensure their students leave high school as STEM-proficient or STEM-advanced.

Learning in the STEM disciplines is experiential, which has two separate implications: 1) a student must have meaningful, relevant experiences in order to understand and to apply STEM; and 2) a student's proficiency declines without early exposure to STEM education and continued experiences in STEM. These experiences must begin at the elementary school level and continue through graduation. Because three years of mathematics and three years of science are the only STEM requirements for Core 40, the basic requirements for a diploma in Indiana, it is possible that many students can finish their STEM course of study by their junior, or even by the sophomore year. Students should be encouraged and expected to take courses in STEM disciplines in every year of their high school careers. Indiana has taken the first step towards this by requiring students to take a math or a quantitative reasoning course each year of high school.

A true STEM curriculum provides points of integration between multiple STEM disciplines and allows students to innovate. STEM courses should provide students with opportunities to innovate and produce, both individually and collaboratively, through real-world applications and projects. These courses should also provide students with engaging, hands-on, and relevant experiences that build logical and quantitative reasoning. Currently, this is not uniformly expected in science, technology, engineering, and mathematics classrooms.

Building STEM courses requires more attention to the *instructional* elements of the classroom than it does the *curricular*. Teachers should encourage students to question and investigate, instead of allowing them to rely upon rote procedures; they should require students to complete projects, instead of relying upon worksheets; they should encourage students to be creative, instead of emphasizing simple application of procedures; and they should teach students to work collaboratively, instead of assuming that this automatically happens when students work in groups.

Although opportunities to build student STEM competency can be included in nearly all courses, certain courses in the K-12 curriculum should have STEM competency as their core focus. These courses include all mathematics, science, computer science, technology, agriculture, health science, career and technical, trade and industrial, and engineering courses. Teachers in these disciplines should evaluate their instructional practices and curricular materials to ensure that they are actively building these competencies in their students.

At the elementary level, the integrated curriculum includes mathematics and science, as well exposure to elements of design and technology. STEM fields should be explored and used to engage state standards. Meaningful learning occurs when learners make connections between prior knowledge and new experiences and skills within real world contexts (Wang, Moore, Roehrig, & Park, 2011). Educators should seek to develop and provide opportunities for students to demonstrate the following core knowledge.

Middle schools need to both strengthen their academic core and establish supportive environments that value the young people they serve. Middle school students are ready to find the relevance of their academics to their world. Curriculum integration at this level is intended to cross subject boundaries and allow for mastering content by gaining experiences from projects, collaboration, group learning, and self- assessment. This is also a time in a student's life during which they undergo a cognitive transition, as they build on knowledge gained at the elementary level and deepen their understanding of information. By using an integrated STEM curriculum, schools ensure that students at the middle level begin to see their academics as part of their preparation for life.

A STEM curriculum adopted by a school must address both the needs of a STEM student (as described above) and the needs of STEM careers. Curriculum is expected to touch each of the STEM core knowledge components throughout the student's academic career. The depth and breadth of each category is determined by the local school's immersion in STEM education. Some of the STEM core knowledge categories will overlap and integrate into most subject areas, as STEM requires intentional integration of subject matter.

Students should become knowledgeable in many areas and be able to readily transfer this knowledge in various scenarios. STEM knowledge and skill are considered, "relatively enduring attributes of an individual's capability for performing a particular range of different tasks" (Carnevale). Table 6 and 7, found in Appendix D, provides a summary of the core knowledge and skills that are essential to STEM fields, as identified by Georgetown University's Center on Education and the Workforce. Any school adopting a STEM curriculum must address the core knowledge and occupation skills or adapt current curriculum in order to address the gaps that may exist.

The Community for Advancing Discovery Research in Education (CADRE) proposes STEM curriculum and instruction engage students with project-based learning. This encourages students to solve real world problems. Student-centered approaches benefits all students. Rather than direct students, teachers set up and facilitate conversations and small-group activities explicitly explaining how to talk with peers about math, science, or other subjects. In this type of learning environment, ongoing feedback is a norm and critical to learning success.

A continued commitment to improving learning outcomes for all students is necessary in all classrooms across the state. As racial, ethnic, socioeconomic, and language diversity continues to increase, the importance of having conversations around equity grows. CADRE has identified the following characteristics, which are typical of schools that support the learning needs of all students:

1. Use of classroom practices that support equity;
2. Connect students' cultural experiences and native languages;

3. Connect to real-world problems;
4. Organize schools to foster equity; and
5. Provide high-quality curricula and instruction to all students.

While many data sets exist to describe math and science achievement gaps, few studies have been conducted to identify particular strategies for closing these growing gaps between advantaged and disadvantaged students. The above characteristics have been identified by researchers as approaches to STEM education that have been shown to produce positive outcomes for a diverse range of students. CADRE points out the importance of educators recognizing the disparities between traditional classroom strategies and what is most meaningful to students' everyday lives and finding ways to bridge the divides.

K-12: Program Assessment

STEM education has shown to improve student performance on standardized tests, including closing the gap between ethnic and socio-economic groups. STEM learning is designed to focus on student engagement, knowledge acquisition, literacy analysis, synthesis, and critical thinking skills that will impact the depth of student learning. It is critical to assess the STEM program of a school from a community level all the way to student level. We strongly recommended to assess the level of STEM support and knowledge of key stakeholders, including but not limited to businesses, parents, administrators, and community members.

At the student level, collecting and analyzing assessment data allows for informed instructional decisions and for students to have greater success in a classroom setting. Teachers should strategically collect and analyze data to gauge students' progress toward their educational goals. According to Tennessee Mathematics, Science and Technology Education Center (TMSTEC), "a well-designed and comprehensive assessment plan is an integral and key component of effective instruction" (STEM resources).

STEM assessment should then be a well planned strategy for collecting information about students' STEM literacy ability and using the information to focus on STEM literacy goals. It is important to note that testing each student's prior knowledge is an imperative part of the teacher's ability to provide rigorous and relevant instruction. As gaps in prior knowledge show up in the STEM pre-testing, a teacher can target those gaps for more effective teaching and learning. The plan should include pre-assessments for prior knowledge, formative assessment for monitoring, and summative assessments for evaluating student performance.

K-12: Professional Development

Instruction models for STEM education require students to be actively engaged in their learning environments. For students to become graduates with the aforementioned abilities, professional development and pre-service training should train teachers to design curriculum that is integrated as well as problem-based. Traditional teaching methods generally do not support STEM instruction, and as such teachers will need to engage in professional learning opportunities to ensure their instructional methods are aligned with best practices in content integration.

Professional development should serve as a catalyst for educator growth and learning. It should focus on developing teachers' capabilities and knowledge to teach and integrate content and subject matter, address classroom work and the problems encountered in teachers' school settings, and provide multiple and sustained opportunities for teacher learning over time (National Academy of Science, 2011). It should be an ongoing process through which teachers strengthen their content knowledge, become skilled at utilizing effective instructional strategies and curricular materials, and increase their ability to address the learning needs of all students. However, professional development in Indiana typically focuses on best practices in individual content areas rather than the integration of science, mathematics, engineering, and mathematics. The following considerations from CADRE should be made when planning professional development:

- Initial training should be aligned with district-specific curricula so that teacher candidates are learning what they actually will be teaching.
- Ongoing professional development must address teachers' classroom work and the problems they encounter in school settings. Teachers should experiment with new strategies in their classrooms, report back on their experiences back to the training program, and ultimately discuss, reflect, and learn from them alongside their colleagues.
- On-site professional support should allow for regular interaction and collaboration with colleagues and school leaders, such as professional learning communities.
- Teachers should be provided multiple and sustained opportunities for continued learning over a substantial time interval.

To maximize impact, administrators should support ongoing learning communities and effectively communicate the benefits of these interactions. Members of these learning communities should collaborate and share ideas with one another. Time should be provided for teachers to interact with each other, as well as district coaches and administrators. Ideally, effective teachers will assume a leadership role in facilitating these discussions.

The implementation of STEM integration includes employing new skills and a variety of challenges for teachers. Educators may need to learn new content, gain experience with different instructional techniques, and implement assessment methods that may require additional learning for teachers (Reyes, Reys, Lapan, Holiday, & Wasman, 2003). Additionally, teachers must address the learning needs of all students, have higher cognitive expectations for students, manage unexpected questions that take lessons in different directions, facilitate different classroom roles for teachers and students, find time to prepare and make hands-on materials, use open-ended problems, and manage time in new ways (Bock, Keusch, & Fitzgerald, 1996; Lappan, 1997; Reys, et al.k 2003; Tetley, 1998).

The following list offers various research based effective models of ongoing professional development that a school could incorporate in their current professional development plan (Journal of Staff Development):

- Individually Guided Staff Development: Participants identify goals and select tasks that will help them to accomplish their goals.
- Observation and Assessment: Participants reflect upon and analyze their roles and contributions in order to improve students' learning.
- Involvement in a development and improvement process: Participants are involved in solving a problem that addresses issues relating to school improvement or curriculum development.
- Training: Participants engage in training to acquire knowledge and develop skills in specific areas.
- Inquiry: Participants, individually or in groups formulate questions and explore possible solutions to those questions.
- Case Development: Participants, through the use of case studies, analyze situations, communicate recommendations, and broaden their understanding of pedagogy and knowledge.
- Professional Learning Community: Participants in a school and their administrators continuously seek and share learning and then act on what they learn. The goal of their actions is to enhance their effectiveness as professionals so that students benefit.

STEM education is not only meant to challenge and expand the capabilities of the students but also the teachers. In order for Indiana schools to have success implementing STEM education, teachers must be provided high quality professional development with varied approaches. Professional development is meant to provide teachers with the requisite content knowledge and pedagogical skill to afford their students quality instruction.

K-12: Teacher Collaboration

Teacher collaboration among STEM educators is an essential component of successful STEM implementation. Professional development and teacher collaboration should be integrated to create a model in which teachers share their expertise to evaluate, create, and model STEM lessons. Providing time and resources for ongoing teacher collaboration is an integral part of the STEM implementation model. In mathematics, the pending implementation of Indiana's Common Core State Mathematics Standards provide an excellent opportunity for teacher collaboration and learning around a new set of standards and expectations. Integrating the implementation of these new standards and the STEM initiative is a natural marriage of teacher and school resources.

K-12: Teacher Accountability Model

The implementation of RISE, the new teacher accountability measures, in Indiana provides an excellent opportunity for a transition to STEM education for teachers and schools. As part of RISE, teachers must demonstrate student centered planning, instruction and collaborative leadership with colleagues. These requirements allow schools and teachers to allocate resources such as time, professional development, professional learning communities, and teacher collaboration to both the STEM Initiatives and Teacher Accountability simultaneously. Implementation of both initiatives can be cost effective for schools and time effective for teachers. In addition, RISE has competencies for communicating content knowledge, engaging students in content to promote mastery, and develop higher levels of understand through rigorous instruction and work, all aligned to STEM education. A successfully implemented STEM immersion school would provide teachers the tools and resources to become highly effective educators as defined by the RISE evaluation.

Component: Higher Education

Higher education plays a particularly important role in STEM education for two parallel reasons: preparing a cadre of STEM teachers and preparing students for STEM careers. It is important to recognize that for higher education to successfully prepare STEM teachers for the classroom and students for the STEM workforce, they may have to change their own instructional practices, recruiting procedures, staffing, and departmental structure.

Higher Education: State of STEM

Higher education plays an important role in preparing students for careers in STEM; in conjunction, there is a disproportionate amount of STEM job openings compared to qualified individuals. For this reason, K-12 education and higher education must work jointly in implementing this plan and align their visions to educate the nation's workforce of the future.

In 2000, the United States ranked 20th in the world for the percentage of 24 year olds who had earned a first degree in a STEM field. Minority groups are underrepresented in STEM fields and will soon make up the majority of children in the country. In order to maintain innovation and advancement, our education should encourage more minority students to enter STEM fields. In order for the proportion of minority students to keep pace with the overall US population, we need to triple the number of minorities entering STEM fields (Olson and Labov, 2012).

In addition, many of the individuals entering STEM majors end up leaving those fields to pursue other degrees. In fact, among all students who had intentions of majoring in a STEM field, only 43% were still in STEM fields at the end of their enrollment and half of the students who left STEM majors changed to business majors. Conversely, only 5.5% of students switch to STEM majors during their undergraduate studies (Olson and Labov, 2012). STEM students in general express dismay with the quality of instruction in their classroom, with 83% of all STEM students indicated poor faculty pedagogy as a major concern. This has direct correlation to the number of students exiting STEM majors, as 42% of the students who left STEM majors cited poor pedagogy as a primary reason for leaving the field. In fact, most faculty at higher education institutions have received little training in pedagogy, assessment, and evaluating teaching effectiveness (Singer, Nielsen, Schweingruber, 2012).

Higher Education: Undergraduate Instruction

A great amount of research has been done into the quality of K-16 instruction. Evidence shows that a critical factor in increasing student comprehension is to increase mental engagement (Ahlfeldt, Mehta, & Sellnow, 2005). In order to increase mental engagement, instructional practices must change across all educational institutions, and often they must vary by content area. A movement exists to improve instruction across the board and shift towards a student-centered instructional model. This model encourages the teacher to take on the role of facilitator. Students are better able to collaborate and work on projects while the instructor monitors student engagement and knowledge. Lecture is still used, but it is not the only technique used by instructors. Research indicates that even just modifying lecture by making it more interactive improves student learning outcomes (Crouch, Watkins, Fagan, & Mazur, 2007). Lectures can be made interactive through question and answer, think-pair-share, and classroom clicker systems. Other instructional techniques should include small group work, problem-based learning, self-directed learning, or blended learning. The following list identified by the Planning Committee on Evidence on Selected Innovation in

Undergraduate STEM education by the National Research Council, provides STEM practices that all STEM courses must include the following:

1. Teaching epistemology explicitly and coherently.
2. Using formative assessment techniques and feedback loops to change practice.
3. Providing professional development in pedagogy, particularly for graduate students.
4. Allowing students to "do" science, such as learning in labs and problem solving.
5. Providing structured group learning experiences.
6. Ensuring that institutions are focused on learning outcomes.
7. Mapping course sequences to create a coherent learning experience for students.
8. Promoting active, engaged learning.
9. Developing learning objectives and aligning assessments with those objectives.
10. Encouraging metacognition.
11. Providing undergraduate research experiences.

National programs are working to improve student instruction. One of the largest resources for undergraduate institutions is SCALE-UP, Student Centered Active Learning Environment for Undergraduate Programs. Project SCALE-UP, located at North Carolina State University, aims to restructure college courses to more student-centered model of instruction. Funded partially by the U.S. Department of Education and the National Science Foundation, their primary intent is to make large enrollment class highly collaborative, hands on, computer rich, and interactive.

Higher Education: Pre-Service Teacher Training

A major concern of the STEM movement across this country is the shortage of highly qualified individuals to teach STEM. As this plan has shown, STEM Education is quite different from traditional education, which may pose a problem for traditional teacher preparation programs. In order to address this concern, teacher preparation programs need to increase the rigor of their curricula and pedagogical instruction. Additional concerns include pre-service STEM educators need a diverse background, which includes diversity in education and demographics; in addition, substantial content knowledge, experience in the field, success with classroom management, and understanding of child development. Innovation in pre-service programming is essential for attracting and retaining high quality STEM educators.

Teach for America, Woodrow Wilson Fellows, and the New Teacher Project are model programs for recruiting and training teachers with diverse backgrounds, including backgrounds in STEM fields. UTeach is a secondary STEM teacher preparation program created by the University of Texas at Austin and is currently in 34 universities across 14 states. UTeach is an example of a traditional teacher preparation program that has found success recruiting and training STEM teachers for the classroom (Wilson, 2011). Teacher preparation programs can gain from researching effective models of preparation in order to retain those STEM qualified individuals in the classroom. Often transition-to-teach programs require new teachers only to complete a rigorous summer preparation program prior to being placed in a classroom. This can quickly lead to burn out for individuals who were unprepared, which may in turn lead to an inability to retain the diverse groups of teachers that these programs are successful in attracting.

All teacher preparation programs can benefit from ongoing evaluation of whether their current instructional practices are adequately preparing teachers to provide students with the skills needed in STEM (Tables 6 and 7). Teacher preparation programs can consider including more content-specific courses, utilizing content-area professors to teach best practices in their subject, fostering collaboration among the education department, the science department, the math department, and the engineering department, providing internships in labs or companies, instituting more intensive and extended mentoring, raising admissions requirements, and consistently reviewing and revising current practices to stay to keep up with innovation.

Improving STEM teacher preparation and ongoing supports is necessary to provide students with educational opportunities on par with the most competitive countries in the world. Professional growth and learning should be ongoing and sustained, supported by administrators and communicated effectively to teachers.

In order to implement change effectively at the undergraduate level a great deal of professional development will be needed for current and future faculty. Delta Program is a program from the University of Wisconsin that aims to improve undergraduate education by preparing faculty to teach, prepare faculty for the demands of their job, and change the culture of higher education. It specifically focuses on improving undergraduate education in STEM fields and advancing effective teaching practices for diverse students. Delta Program is part of the Center for Integration of Research, Teaching, and Learning, a network of 25 research universities that promote STEM faculty development. Professional development must be sustained and ongoing, aligned to adult educational research, and engage faculty in their teaching practices.

Higher Education: Increasing Minority Recruitment

Attracting minority and first generation college students requires a greater degree of outreach, community education, mentoring, and financial support. Navigating applications, financial aid, and enrollment processes are common obstacles for these students. In 2009, according to the U.S.Census Bureau's American Community Survey, 72% of STEM workers were white, while only 6% each for Hispanics and Blacks. From that same survey, only 14% of Hispanics and 22% of Blacks had a college degree, compared to 35% for Whites. This data shows a large disparity in the opportunity of minorities to not only go to college but also to enter the STEM workforce. If this isn't addressed through aggressive recruitment, the inequality will only increase.

State and national programs are designed to educate high school and college students about the admissions process in STEM fields. For example, Advanced Technical Education Centers help provide these opportunities to students and make a concerted effort to educate minority students about STEM careers. The National Science Foundation funded the Model Replication Institution (MRI). This program, "sought to improve the quality, availability, and diversity of STEM education." This program identified critical components that universities must provide in order to improve their minority recruitment:

- Precollege initiatives to prepare students for success in college
- Student support, i.e., social, financial, academic
- Undergraduate research to involve students directly
- Faculty development to retain quality STEM faculty
- Curriculum development to make concepts relevant to student and community populations
- Upgrade facilities and equipment
- Facilitate admissions into STEM graduate programs

These recommendations will also provide guidance for recruiting students as a whole. It is difficult to identify any one method that would increase recruitment for a specific race or background (Institute for Higher Education Policy, 2007). However, by providing students of diverse backgrounds the support structures they need to apply and making a concerted effort to attract those students, universities will see a rise in the minority populations progressing into STEM majors.

Higher Education: Expanding High School Courses

In order for higher education institutions to recruit students to STEM majors, high schools must promote advanced STEM courses. Some programs are already in place within Indiana, such as International Baccalaureate (IB), Dual Credit, and Advanced Placement (AP) courses, which enable both advanced and students who qualify for the opportunity to obtain college credit while in high school. Enrollment in these courses can motivate students to engage in their education and reduce the financial burden of college tuition. The Indiana Department of Education is committed to increasing the number of students taking and excelling AP and Dual Credit courses. In 2011, data from the IDOE showed gains across the board in the number of students taking AP exams in the STEM fields, 61% of all exams taken. The number of students taking exams has increased as well, from 15,717 in 2009 to 18,726 students in 2011 and early indicators show that number should exceed 22,700 students for 2012. While this indicates positive growth with AP; overall, Calculus AB, Chemistry, and Biology demonstrated little change in performance over that same time.

Researchers from the Texas Higher Education Coordinating Board and the University of Texas at Austin assessed the college success of every Texas public school student who entered a Texas public college or university from 1998 to 2002, following them through their years in higher education. Because of the large sample size and research timeframe, this is the most substantive analysis of the relationship between AP, dual enrollment, and college success that has ever been conducted. At a purely descriptive level, the study reports on the percentage of students who earned a bachelor's degree within 4 years. Students that earn a qualifying/ passing mark on an AP exam have greater probability of graduating in 4 years or less and earning a higher GPA than students that have not done so. Indiana has partnered with the National Math and Science Initiative, NMSI, to increase the number of students taking and having success in math and science AP courses as well as English. This program begins educating teachers and students very early in their educational career to prepare them for AP courses. STEM education also seeks to prepare students in math and science starting in early childhood, which would prepare students for the rigor of AP courses aligning this STEM plan with the current state AP initiative.

COMPONENT: Business and Industry

Businesses are becoming increasingly aware of how they can respond to their own needs as well as those of society by engaging in the community and schools. Indiana's business community has a vested interest in the success of STEM education because they require a well-educated pipeline of employees to fill positions now and in the future. Without this pipeline, Indiana could see business either leaving the area or recruiting from other states and countries. Working together, schools and business can create a relationship, benefiting both parties. (Rochlin & Christoffer, 2000)

Business and Industry: Promoting STEM

Business and industry will be a able to provide a great deal of support for promoting STEM education throughout the state and within communities. Efforts to increase STEM education in the state of Indiana will require motivating business to get involved by lobbying for policies and programs that will support STEM education in schools. Business and industry needs to be strategic with their involvement in education and align their, "philanthropic, government relations, employee involvement, and other business activities with their STEM objectives. " (Change The Equation, 2012) In addition, if businesses work together there is collective impact around STEM and this will sustain change and reduce the chances of one off programs that eventually fall by the wayside. This collective impact also provides strength in numbers with driving policy change or even just communicating a message. Employees are a great resource that could be tapped for promoting STEM or working on the next sections. However, they need to be communicated with and understand the vision for STEM that the business has. Employees usually live in the community and have a vested interest in the education of the community so using them as a resource is essential. Finally, business and industry usually has partnerships or sponsorships that could be leveraged to support STEM education. (Change The Equation, 2012)

Business and Industry: Mentoring

Research supports the need for colleges and universities to provide mentoring to students in STEM fields. While many graduates, professionals, and tradesmen receive mentoring upon entering their professions, this process can be accelerated by providing these opportunities for students at the undergraduate level as well. Research shows that mentored students are retained at a higher level resulting in students' acquiring knowledge and skills more effectively. Students benefit from mentoring by university faculty, as well as outside organizations including business and industry (Olson & Labov, 2012).

Business and Industry: Research, apprenticeships and Internships

Students' engagement in research, apprenticeships and internships is considered one of the most effective ways to retain students in the STEM majors and fields. Internships and research opportunities at the high school and college level can make the students' education relevant and personally engaging.

Opportunities to engage in their field are studying provides real world perspective. Students who participate in research, apprenticeships or internships are more likely to determine their career choice as an undergraduate.

Business and Industry: Resources

Schools are constantly looking for resources and this is a wide range from human capital to money to materials. Schools are often underfunded, undermanned, and undersupplied and a STEM school may need more resources than the traditional school especially if the students are to participate in real world problem solving and exploration. Business and industry can supply resources in the form of supplies and materials. This could be from the basic office supplies all students and teachers need as well lab ware, technology and software, machines, etc. Teachers need a variety of supplies and materials in order to achieve a project or inquiry based classroom. Having enough materials for the number of students being taught can be draining on a teacher's budget. Partnering with a local business or industry could help, even if materials are just on loan. In addition, schools can help the business by allowing appropriate advertising and marketing or logos on newsletters and school equipment. Business and industry can also supply human capital. The experts of a particular field are currently working in that field. Schools need to bring those experts into the classroom to help the teacher with projects and to work with students. This will develop student and teacher interest in the subject.

Indiana Department of Education

The Indiana Department of Education (IDOE) must take the lead role to ensure the success of STEM education in Indiana. Currently, there are many initiatives the IDOE has implemented to increase the academic achievement of all students. STEM education can be the plan schools and districts follow that encompasses all the initiatives and be the driving force elevating student achievement. In order for this to happen, IDOE will have to increase educator awareness around STEM, collaborate with business, higher education, and communities, and change policies to free schools of restrictions that may prevent successful STEM education.

Indiana Department of Education: STEM Awareness and Training

Many educators have not yet come to the realization that STEM education is more than simply a new name for the traditional approach to teaching science and mathematics. Nor do they understand that it is more than just the grafting of “technology” and “engineering” layers onto standard science and mathematics curricula. As a result, there is little to no thoughtfully planned and implemented STEM curriculum in secondary schools (Lantz, 2009). The IDOE will have to take the lead in developing resources and professional development. In order to successfully implement STEM instruction, educators will need a great deal of professional development to increase content knowledge as well as pedagogy. The IDOE will create partnerships with teacher organizations, higher education, and business in order to facilitate effective professional development for STEM educators. In addition to developing current teachers, IDOE will need to address the increased demand for STEM teachers by increase routes of entry into STEM teaching. Once again, this will take partnering with higher education to create STEM preparation programs for educators as well as identifying pathways for STEM workforce to enter the classroom as an educator.

Indiana Department of Education: STEM Courses and Curriculum

In order to adequately address the educational requirements of STEM education and the STEM career needs of the state, the Indiana Department of Education will need to develop new courses and standards. This could include, similar to Career and Technical Education, STEM pathways that address the needs of the state and develop courses aligned to STEM careers. The Indiana Department of Education will also need to identify high quality STEM course curriculum aligned to the Indiana Academic Standards and Indiana's Common Core Standards for Mathematics. If no high quality STEM curriculum exists specific to the needs of Indiana careers, the IDOE will need to develop the tools and resources necessary to guide local school districts in their own development of curriculum.

Indiana Department of Education: Policy

While many policies have the intention to push education reform, it is important to be sure the policies are in line with quality educational research. In many ways, STEM education is a non-traditional form of educating students, the policies that apply to a traditional school may have no bearing in a STEM school. It will be important for the IDOE to identify policies that encourage and allow schools to implement STEM education. Policies to consider are as follows:

- Create an IDOE-STEM division to coordinate all aspects of STEM education including but not limited to formal and informal STEM education, organizations, businesses, professional development, resource coordination, and school credentialing,etc.
- Teacher Licensing: STEM schools will require a different set of teachers with a variety of skills and training. Licensing individuals that may not have come from schools of education but came from STEM

workforce would be an option to fill this need. Training will be highly important for these transitional individuals. With the creation of new STEM courses, licensing for these courses will need to be considered and adapted as needed.

- Graduation Requirements: Graduation requirements for STEM individuals may be more in line with Indiana’s Technical Honors Diploma, however, the IDOE may consider alternative requirements for STEM graduates. Including four years of science and math, additional requirements for engineering and technology courses as well as workforce specialty courses and on the job training/ internships. With a possible monetary incentive for the schools who graduate with a STEM recognized diploma.
    - STEM Honors Diploma – would require 8 credits of math and Science and Engineering/Technology
    - STEM Diploma that would align with a certification or an AAS degree
- Academic courses: The academic coursework Indiana currently has offers a wide variety for students, but STEM is a specific domain of the workforce and requires courses specific for these disciplines of STEM. STEM courses will need to be identified and then offered and may be specific to a region in the state to allow for career pathways, similar to Career and Technical Education.
    - Align with CIP codes of which are STEM careers and STEM degrees
- Course Pathways: Career and Technical Education has already begun work in this area but with STEM schools, pathways should be expanded to other disciplines of STEM. Students need identified pathways for careers in advanced sciences and mathematics. For example if a student wishes to become a chemical engineer, schools may offer a pathway with expanded courses offering that would build the foundation for this career, leading to greater success in college and careers. It also allows students to, “Test the water” before going to college.
    - Designate pathways as STEM pathways not create STEM pathways
    - Within pathways identify math and science needed to succeed in the STEM career
- School funding: STEM schools may require additional funding or at least greater freedom in their budget and sources of funding. STEM education often requires more money due to the advanced technology or education of the instructor.
    - Best practices of the schools to continue to improve STEM environment
- School accreditation: Indiana will need a comprehensive system and criteria to identify a school as a STEM school and the IDOE will need to identify the criteria and develop the rubric.
    - Build a system to identify schools as a STEM school and at what level of immersion a school can progress to.
- Accountability: Science will need to be added to the school accountability system for elementary, middle, and high schools as well as the addition of assessing science at least every other year.
    - For core 40 and STEM Advanced Diploma students must pass high school Science ECAs in Chemistry, Physics, and beyond
    - A continuation of the initiative to test science yearly

Works Cited

Ahlfeldt, S., Mehta, S., & Sellnow, T. (2005). *Measurement and analysis of student engagement in university classes where varying levels of PBL methods of instruction are in use.* Crawley: High Education Research and Development.

Beth, A., Robinson, M., Romero, P., & Perez, M. (2012). *Implementing a Secondary STEM Teacher Preparation Program at Multiple Universities: The UTeach Institute's Evaluation Approach and Pilot Summative Date.* Vancouver: American Educational Research Association.

Business Roundtable. (2008). *Tapping America's Potential: Gaining Momentum, Losing Ground.* Washington DC: Business Roundtable.

Carnevale, A., Smith, N., & Melton, M. (2011). *STEM: Science Technology Engineering Mathematices.* Washington DC: Georgetown University Center on Education and the Workforce.

Change The Equation. (2011). *Indiana STEM Vital Signs.* Washington DC: Change The Equation.

Change The Equation. (2012). *VitalSigns: STEM Help Wanted.* Washington DC: Change The Equation.

Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology. (2007). *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future.* Washington DC: National Academy of Sciences.

Committee on Public Understanding of Engineering Messages. (2008). *Changing the Conversation: Messages for Improving Public Understanding of Engineering.* Washington DC: National Academies Press.

Committee on Technological Literacy. (2002). *Technically Speaking: Why All Americans Need to Know More About Technology.* Washington D.C.: National Academy Press.

Crouch, C., Watkins, J., Fagan, A., & Mazur, E. (2007). *Peer instruction: Engaging students one-on-one, all at once.* Cambridge: Physics Education Research.

Institute for Higher Education Policy. (2007). *Diversifying the STEM Pipeline: Recommendations from the Model Replication Institutions Program.* Washington DC: Institute for Higher Education Policy.

International Technology Education Association. (2009). *The Overlooked STEM Imperatices: Technology and Engineering.* Reston: International Technology Education Association.

Katehi, L., Pearson, G., & Feder, M. (2009). *Engineering in K-12 Education: Understanding the Status and Improving the Prospects.* Washington DC: National Academies Press.

Lantz, H. (2009). *Science, Technology, Engineering, and Mathematics (STEM) Education What form? What Function?* Baltimore: CurrTech Integrations.

Meyrick, K. (2011). *How STEM Education Improves Student Learning.* Raleigh: Meridian K-12 School Computer Technology Journal.

National Science Board. (2006). *America's Pressing Challenge - Building A Stronger Foundation.* Arlington: National Science Foundation.

Olson, S., & Labov, J. (2012). Community Colleges in the Evolving STEM Education Landscape: Summary of a Summit. *Community Colleges in the Evolving STEM Education Landscape: Summary of a Summit* (p. 134). Washington DC: National Academies Press.

PTC-MIT Consortium EDC. (2006). *Preparing for the Perfect Storm: A Report on the Forum "Taking Action Together: Developing a National Action Plan to Address the 'T&E' of STEM".* Reston: PTC-MIT Consortium EDC.

Rochlin, S., & Christoffer, B. (2000). *Determining the Value of Corporate Community Involvement.* Boston: The Center for Corporate Citizenship at Boston College.

Tsupros, N., Kohler, R., & Hallinen, J. (2009). *STEM Education:A Project to Identify the Missing Components.* Washington: Intermediate Unit 1: Center for STEM Education.

Wilson, S. (2011). *Effective STEM Teacher Preparation, Induction, and Professional Development.* Washington DC: National Academies Press.

Yazzie-Mintz, E. (2009). Charting the Path from Engagement to Achievement. *High School Survey of Student Engagement* , 1-28.

Appendix A: ISTEP+ Data

Table 1
ISTEP+ Mathematics Results Overview 2005-2011

Years	% Passing Grade 3	% Passing Grade 4	% Passing Grade 5	% Passing Grade 6	% Passing Grade 7	% Passing Grade 8
05-06	74%	76%	77%	79%	77%	73%
06-07	73%	75%	77%	81%	78%	72%
07-08	71%	76%	78%	81%	80%	75%
08-09	71%	74%	78%	80%	82%	76%
09-10	77%	77%	82%	79%	75%	75%
10-11	78%	79%	86%	80%	75%	77%

Table 2
ISTEP+ Science Results Overview 2005-2011

Years	% Passing Grade 4	% Passing Grade 5	% Passing Grade 6	% Passing Grade 7
05-06	*N/A	57%	*N/A	49%
06-07	*N/A	57%	*N/A	51%
07-08	*N/A	57%	*N/A	51%
08-09	71%	*N/A	54%	*N/A
09-10	77%	*N/A	59%	*N/A
10-11	76%	*N/A	62%	*N/A

*In Indiana, students are currently tested in science knowledge at the 4th and 6th grade levels. Prior to 2009, students were tested in science at the 5th and 7th grade.

Appendix B: STEM Proficient and Advanced Student Criteria

Table 3
STEM Proficient Student

Domain	Criteria
Core Knowledge	• Utilizes connections between disciplines to solve problems • Applies interdisciplinary connections between disciplines to investigate and answer complex issues • Evaluates appropriate sources of data to solve problems • Presents data in diverse formats • Communicates using discipline specific vocabulary • Engages in critical reading and writing of technical information • Develops evidence based claims • Asks questions to identify complex issues and real world problems • Conducts research to refine hypothesis or claims • Thinks critically • Applies appropriate systematic approaches to an investigation whether it be scientific or engineering practices, engineering design, or mathematical practices • Collaborates as team with students and teachers • Participates in discussion and constructive argument • Analyzes STEM Careers and skills relevant to those fields
Required Courses: Based on Indiana Academic Standards and Indiana Common Core Standards	• Algebra I & II, geometry, biology, chemistry, physics o At a minimum, 6 credits in mathematics, 6 credits in science, and additional credits in computer science and engineering
Recommended Courses	• Statistics, trigonometry, physics, computer science, engineering, environmental science, and geology

Table 4
STEM Advanced Student

Domain	Criteria
Core Knowledge	• Utilizes connections between disciplines to solve problems • Applies interdisciplinary connections between disciplines to investigate and answer complex issues • Evaluates appropriate sources of data to solve problems • Presents data in diverse formats • Communicates using discipline specific vocabulary • Engages in critical reading and writing of technical information • Develops evidence based claims • Asks questions to identify complex issues and real world problems • Conducts research to refine hypothesis or claims • Thinks critically • Applies appropriate systematic approaches to an investigation whether it be scientific or engineering practices, engineering design, or mathematical practices • Collaborates as team with students and teachers • Participates in discussion and constructive argument • Analyzes STEM Careers fields and skills relevant to those fields • Applies STEM disciplines and their integration to construct creative and innovative ideas, solutions, and/or products • Analyzes the scale of problems and global issues • Analyzes the limits and drawbacks of certain technologies • Improves and creates new technologies to extend the human capability • Uses and creates models to represent real-world applications
Coursework	• Algebra I & II, geometry, biology, chemistry, physics, statistics, trigonometry, physics, computer science, engineering, environmental science, and geology o Minimum 8 credits in mathematics (through pre-calculus), 6-8 credits in science, additional credits in computer science and engineering

Appendix C: STEM Immersion Matrix

Table 5
STEM School Immersion Defined

Full STEM Immersion[2]	Whole school or district STEM initiatives. This is a non-traditional model of education in which the classroom resembles a work environment and students contribute to solving problems in the community. STEM careers, experiences, and skills drive the curriculum. Curriculum is integrated in authentic problem-based learning that is STEM career oriented and cross disciplinary. Students collaborate in teams to solve problems. Teachers facilitate teams of students towards solving problems and developing work force skills, commonly the skills required by STEM businesses in that area or region. Frequently, schools have partnerships with businesses to provide materials, resources, and capital.

- Instruction: Students engage in project-based learning that offers real world, relevant and complex problems. This may include internships, co-ops, work studies, mentorships, and job shadowing. Classrooms are facilitated by teachers who guide students to ask questions, research, solve problems and develop new technologies. This method of learning is offered to the whole student body.
- Courses and Curriculum: Courses must still be aligned to Indiana Academic Standards and Indiana's Common Core Standards. However, the school may create new courses that integrate standards from multiple courses that may span a year or more. Schools may offer licensing, certifications, and possibly associate degrees. These schools offer college-level coursework and workforce skill development.
- Scheduling: Schools are innovative with scheduling. Classes may be several hours or possibly even the whole day. Courses are strategically scheduled to provide a natural progression from subject to subject. Courses may be combined with multiple teachers spanning multiple periods.
- Partnerships: Schools develop higher education and business partnerships, not only for funding and resources but also for guidance and human capital. The school may base its instruction on the types of partnerships it makes, tailoring curriculum to the skills required by local businesses and universities.
- Collaboration: Total STEM immersion is a highly collaborative environment between teachers, students, staff, and community. Teachers have common planning times in order to collaborate. Teachers may be offered the freedom to partner with each other to create new STEM opportunity classes; for example, the opportunity to write grants and create new technologies. This might team an English teacher with an engineering teacher. Teachers collaborate with external school partners to integrate those opportunities in the classroom. Students work in teams towards goals. Students collaborate with teachers, often changing the traditional teacher-student relationship to a more collegial relationship.
- Extended Opportunities: Learning does not stop at the end of the school day. This type of school offers opportunities outside of the classroom and school through afterschool

[2] Modified from the STEM Immersion Matrix for Schools and Districts © 2012, The Immersion Guide © 2013, created by and work product of The Arizona STEM Network, led by Science Foundation of Arizona in collaboration with Maricopa County Education Service Agency.

programs, volunteering, work studies, etc. Often the school staff participate in or even runs the programs for extended learning.

- Model Schools: Bloomington New Tech High School, Hammond Academy of Science and Technology, New Tech Institute
    - These schools have been identified as Total STEM Immersion. The IDOE identifies these schools solely to provide examples of schools trying to implement this type of STEM involvement and not a verification of the school's success.

Partial STEM Immersion[3]	This is a non-traditional school experience. STEM experiences and related skills are integrated into the curriculum. The STEM program may be school wide, with teachers collaborating across disciplines for long term projects. These projects may be in addition to the normal curriculum or used to enhance the educational process. This may also include a school in which only a portion of the student body participates in these long term projects, interdisciplinary learning, or STEM career-based courses in CTE. Frequently the schools maintain business partnerships for materials, resources, and capital.

- Instruction: While partial STEM immersion schools provide traditional schools experiences, they also provide non-traditional STEM experiences either to part of the student body or in specific tracks. Classes may still be the typical length but are highly project or inquiry based and allow students to solve real world problems that are relevant to them. Many offer co-op, internship, or work study programs in addition to the school's normal course offerings.
- Courses and Curriculum: Courses must still be aligned to Indiana Academic Standards and Indiana's Common Core Standards. However, the school may create new courses that integrate standards from multiple courses that may span a year or more. Schools may offer licensing, certifications, and possibly associate degrees. These schools offer college-level coursework and workforce skill development.
- Scheduling: Schools are innovative with scheduling. Courses may be strategically scheduled to provide a natural progression from subject to subject. Courses may be combined with multiple teachers spanning multiple periods. If only offering STEM education to a portion of the student body, schools alter schedules appropriately to offer a school within a school or a STEM track to interested students.
- Partnerships: Schools develop higher education and business partnerships, not only for funding and resources but also for guidance and human capital. The school may base its instruction on the types of partnerships it makes, tailoring curriculum to the skills required by local businesses and universities.
- Collaboration: Partial STEM immersion schools are highly collaborative. Teachers have common planning times in order to collaborate. Teachers may be offered the freedom to partner with each other to create new STEM opportunity classes. Teachers collaborate with school partners to integrate those opportunities in the classroom. Students work in

[3] Modified from the STEM Immersion Matrix for Schools and Districts © 2012, The Immersion Guide © 2013, created by and work product of The Arizona STEM Network, led by Science Foundation of Arizona in collaboration with Maricopa County Education Service Agency.

teams towards goals. Often the school still has traditional teaching situations in which teachers do not cross collaborate for multidisciplinary units.

- Extended Opportunities: Learning does not stop at the end of the school day. This type of school offers opportunities outside of the classroom and school through afterschool programs, volunteering, work studies, etc. Often the school staff participates in or runs the programs for extended learning.
- Model Schools: Helfrich Park STEM Academy, Harshman STEM Magnet Middle School
  - These schools have been identified as Partial STEM Immersion. The IDOE uses this solely to provide examples of schools trying to implement this type of STEM school and not a verification of the success the school is having.

Minimum STEM Immersion[4]	This is a traditional school setting. STEM-related problem-based learning is supplemental to the adopted curriculum. This could include separate STEM units, often done at the end of a unit or school year. It could also include short units offered by industry or non-profits such as Project Learning Tree or National Energy Foundation. These units serve to briefly provide STEM experiences to students and develop skills required in the workforce.

- Instruction: Instruction occurs during the typical content area course period and is usually conducted by one teacher.
- Courses and Curriculum: Teachers incorporate units of STEM study into their traditional curriculum.
- Scheduling: Schools use the traditional schedule of classes having students go to individual classes taught by teachers of one subject area.
- Partnerships: Partnerships may still be made but are often used for monetary and equipment purposes instead of development of human capital.
- Collaboration: Teacher collaboration is important in any school setting. The Minimum STEM immersed school may or may not collaborate for cross-disciplinary instruction.
- -Extended Opportunities: School may provide outside of school STEM related activities.

Supplemental STEM[5]	Schools may offer STEM experiences that are not a part of the regular school day. This may include but is not limited to afterschool programs, summer programs, school clubs, and academic competitions and fairs.

- Supplemental STEM schools follow much of the same criteria as a Minimum STEM Immersed school. However, these opportunities are typically offered as a program outside of normal instruction in STEM.

[4] Modified from the STEM Immersion Matrix for Schools and Districts © 2012, The Immersion Guide © 2013, created by and work product of The Arizona STEM Network, led by Science Foundation of Arizona in collaboration with Maricopa County Education Service Agency.

[5] Modified from the STEM Immersion Matrix for Schools and Districts © 2012, The Immersion Guide © 2013, created by and work product of The Arizona STEM Network, led by Science Foundation of Arizona in collaboration with Maricopa County Education Service Agency.

Appendix D: STEM Knowledge and Skills

Table 6
STEM Domain Specific Core Knowledge

Production and Processing	Knowledge of raw materials, production processes, quality control, costs, and other techniques for maximizing the effective manufacture and distribution of goods.
Computers and Electronics	Knowledge of circuit boards, processors, chips, electronic equipment, and computer hardware and software, including applications and programming.
Engineering and Technology	Knowledge of the practical application of engineering science and technology. This includes applying principles, techniques, procedures, and equipment to the design and production of various goods and services.
Design	Knowledge of design techniques, tools, and principles involved in production of precision.
Building and Construction	Knowledge of materials, methods, and the tools involved in the construction or repair of houses, buildings, or other structures such as highways and roads.
Mechanical	Knowledge of machines and tools, including their designs, uses, repair, and maintenance.
Mathematics	Knowledge of arithmetic, algebra, geometry, calculus, statistics, and their applications.
Physics	Knowledge and prediction of physical principles, laws, their interrelationships, and applications to understanding fluid, material, and atmospheric dynamics, and mechanical, electrical, atomic, and subatomic structures and processes.
Chemistry	Knowledge of the chemical composition, structure, and properties of substances and of the chemical processes and transformations that they undergo. This includes uses of chemicals and their interactions, danger signs, production techniques, and disposal methods.
Biology	Knowledge of plant and animal organisms and their tissues, cells, functions, interdependencies, and interactions with each other and the environment.

Table 7
STEM Occupation Skills

Mathematics	Using mathematics to solve problems.
Science	Using scientific rules and methods to solve problems.
Critical Thinking	Using logic and reasoning to identify the strengths and weaknesses of alternative solutions, conclusions, or approaches to problems.
Active Learning	Understanding the implications of new information for both current and future problem solving and decision making.
Complex Problem Solving	Identifying complex problems and reviewing related information to develop and evaluate options and implement solutions.
Operations Analysis	Analyzing needs and product requirements to create a design.
Technology Design	Generating or adapting equipment and technology to serve user needs.
Equipment Selection	Determining the kind of tools and equipment needed to do a job.
Programming	Writing computer programs for various purposes.

Quality Control Analysis	Conducting tests and inspections of products, services, or processes to evaluate quality or performance.
Operations Monitoring	Watching gauges, dials, or other indicators to make sure a machine is working properly.
Operation and Control	Controlling operations of equipment or systems.
Equipment Maintenance	Performing routine maintenance on equipment and determining when and what kind of maintenance is needed.
Troubleshooting	Determining causes of operating errors and deciding what to do about it.
Repairing	Repairing machines or systems using the needed tools.
Systems Analysis	Determining how a system should work and how changes in conditions, operations, and the environment will affect outcomes.
Systems Evaluation	Identifying measures or indicators of system performance and the actions needed to improve or correct performance, relative to the goals of the system.
Problem Sensitivity	The ability to tell when something is wrong or is likely to go wrong. It does not involve solving the problem, only recognizing that there is a problem.
Deductive Reasoning	The ability to apply general rules to specific problems.
Inductive Reasoning	The ability to combine pieces of information to form general rules or conclusions (includes finding a relationship among seemingly unrelated events).
Mathematical Reasoning	The ability to choose the right mathematical methods or formulas to solve a problem.
Number Facility	The ability to add, subtract, multiply, or divide quickly and correctly.
Perceptual Speed	The ability to quickly and accurately compare similarities and differences among sets of letters, numbers, objects, pictures, or patterns. The things to be compared maybe presented at the same time or one after the other. This ability also includes comparing a presented object with a remembered object.
Control Precision	The ability to quickly and repeatedly adjust the controls of a machine or a vehicle to exact positions.